I. Plasma Arc Spot Welding of Lightweight Materials

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Contractor: U.S. Automotive Materials Partnership
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Objective

- Develop and verify the welding technology required for the joining of lightweight materials (aluminum and magnesium) using Plasma Arc Spot Welding technology.
- Develop the necessary weld parameters and techniques required for a robust joining process.

Approach

This project was divided into three phases: testing, analysis, and summary.

- Produce approximately 6000 material coupons to be used for tensile, shear, and metallurgical analysis and testing (Phase I).
- Determine the material alloys based on Phase I results (Phase II).
- Produce guidelines for welding parameters and quality control (Phase III).

Accomplishments

- Successfully completed fatigue testing at Coventry University.
- Completed data comparison (plasma arc spot welds, resistance spot welds, and rivets).
- Adapted plasma arc spot weld process to join magnesium sheet stock with filler wire.
- Developed guidelines for testing mechanical properties of the new technology that are appropriate for the various applications.

Future Direction

- Complete project and produce Final Report for presentation to U.S. Automotive Materials Partnership

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Introduction

The overall deliverable for this project is a robust process to join lightweight materials economically. Current technology relies heavily on conventional resistance spot welding. High maintenance, tip wear, and accessibility continue to be major concerns. Rivets and/or mechanical clinching are costly alternatives that require high capital investment. The viability of plasma arc spot welds has been validated through the efforts of Arc Kinetics, Ltd., which developed a single-sided plasma arc spot welding process for Jaguar. It was used for joining the sheet metal floor pan assembly, which was not accessible with conventional resistance spot welding equipment. Arc Kinetics also developed a process called aluminum plasma arc welding (APAW). By combining the two processes (single-sided spot welding and APAW), Arc Kinetics developed a process that demonstrates excellent potential for joining lightweight materials.

Status

- Coupon production complete.
- Fatigue testing complete.
- Modified equipment to trial joining magnesium sheet stock AZ31A utilizing TIG filler wire AZ92A. (Spooled magnesium wire cost prohibited if available.) Due to timing and funding constraints, magnesium investigation was terminated.
- Project complete.
- Preparing final report (available first quarter 2005).

Conclusions

- Absorbed hydrogen compounds (i.e., hydrated oxides) in the surface films of sheet aluminum and magnesium at present require a phosphoric acid-based pretreatment prior to plasma arc spot welding to eliminate haloes.
- The addition of appropriate amounts of 4047 grade filler wire appears to eliminate microcracking within the spot welds.
- Destructive testing of spot welds by torsional shear is valuable for assessing the likely strength, degree of macroporosity, and material thinning through the outgassing effects of the welds.
- Plasma arc spot welds typically offer tensile shear strengths 40% higher than those of competitive technologies.
- Under ac welding conditions used in this project, use of a convex radiused tip geometry prevents damage to the plasma torch nozzle through double arcing.
- Service intervals in excess of 3000 welds can be achieved for the consumables associated with plasma arc spot welding. This greatly exceeds service intervals associated with resistance spot welding of lightweight materials.
- Hard anodizing of an aluminum shield cup of appropriate design can produce a cup that is lower in cost and more robust than the ceramic-coated copper alloy shield cups previously associated with the process.
- A flat-surfaced backup positioned between 0.75 mm and 1.0 mm below the lower sheet surface gives better performance in terms of weld quality than do alternative geometries.